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PUBLIC AFFAIRS OFFICE  
NAVAL AIR SYSTEMS COMMAND

*A. Howard*



## ***Aerospace Medical Association 72<sup>nd</sup> Annual Scientific Meeting***

May 6-10      Reno, Nevada

### **Human Factors Considerations in the X-31 Aircraft**

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Naval Air Warfare Center – Aircraft Division  
Patuxent River, Maryland

## ***Introduction***

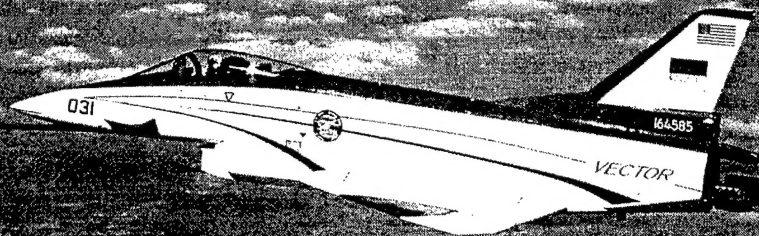
- **Purpose**

- Provide an insight to human factors issues that are relevant to the X-31 ESTOL maneuver

- **Background**

- US Navy Crew System Department human factors lead engineer for the Vectoring ESTOL Control Tailless Operation Research (VECTOR) Program

## *Aircraft Description*



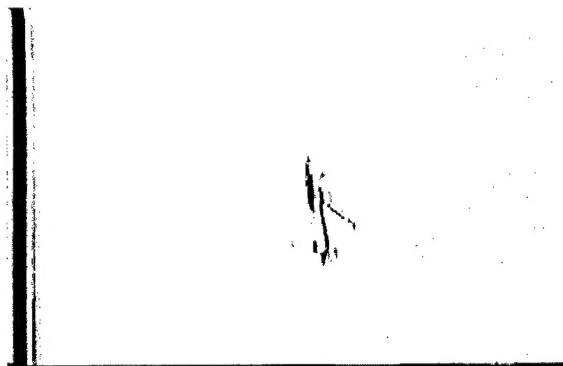
Integration of components from several aircraft

Canards

Expendable missiles

Targeting system

## *1995 Paris Air Show Video*

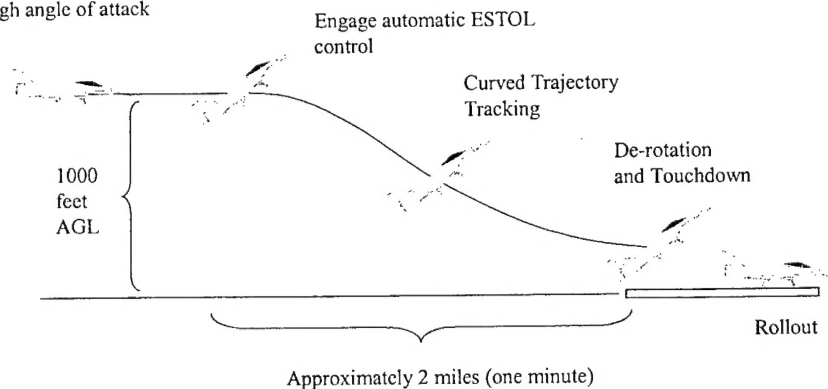


## ***ESTOL Maneuver***

- **High alpha approach with derotation just prior to touchdown**
  - Design goal 40° alpha
    - Best payoff 25°
  - Automatic (hands off) approach and touchdown
    - Integrated Beacon Landing System (IBLS)
- **Pilot will not have direct view of runway environment**
  - Specialized display symbology
  - Indirect view of runway environment
  - Reduced workload
    - HOTAS controls
    - Location of other cockpit controls

## ***ESTOL Approach Profile***

Manually enter window and transition to high angle of attack



## ***Human Factors Issues***

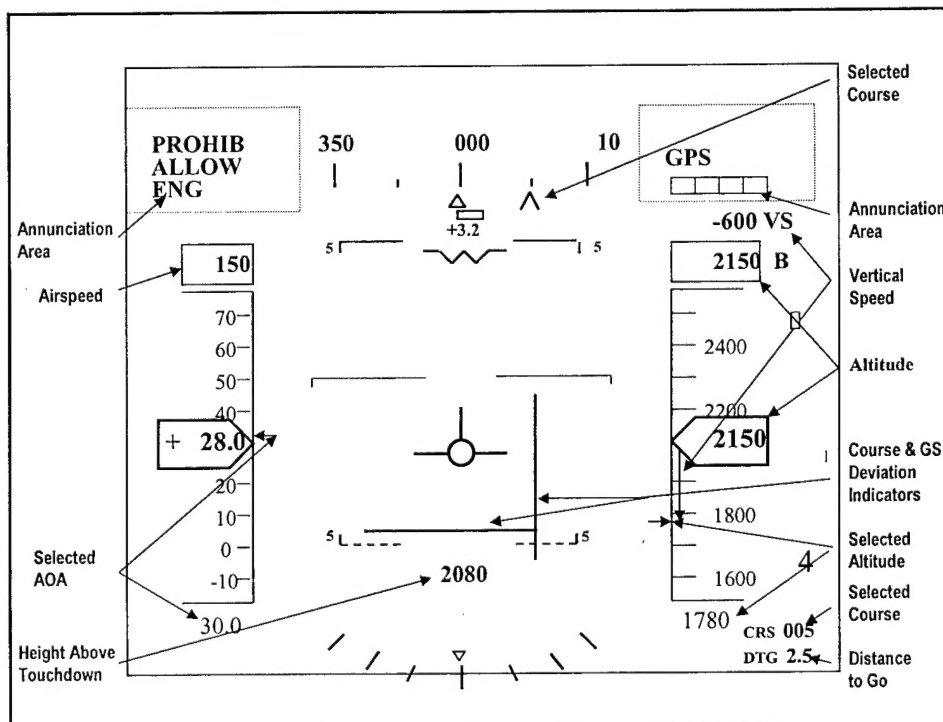
- Display symbology
- Video
- HOTAS and other pilot controls
- Ejection seat
- O<sup>2</sup> regulator
- Communications ear plug (CEP)

## ***Symbology***

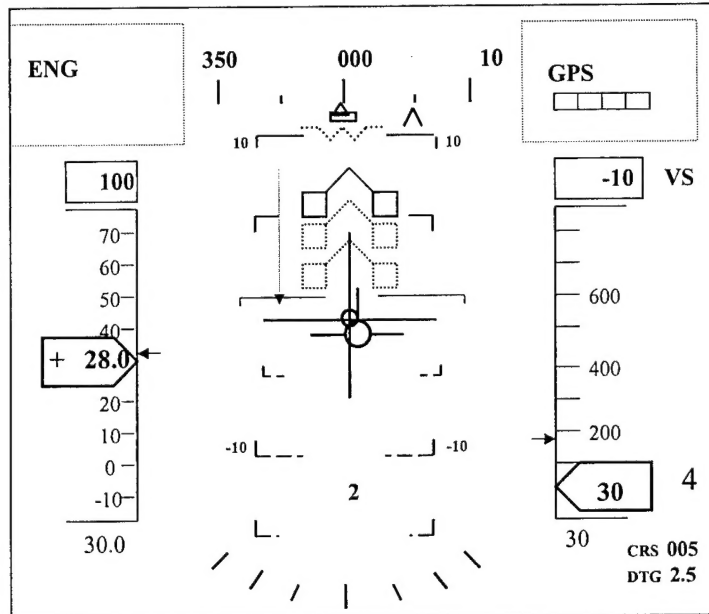
- **Modified to meet ESTOL flight profile**
  - ESTOL-specific symbology
    - Declutter during standard operations
  - Centralized scan of display
- **Primary flight display during approach**
  - HUD vs DDI
    - Opto-Kinetic Cervical Reflex
      - Difficult to assess in simulator
    - Display symbology in both displays
      - Ease of transition from DDI to HUD
      - A/C vs VV centered displays

## ***ESTOL-Specific Symbolology***

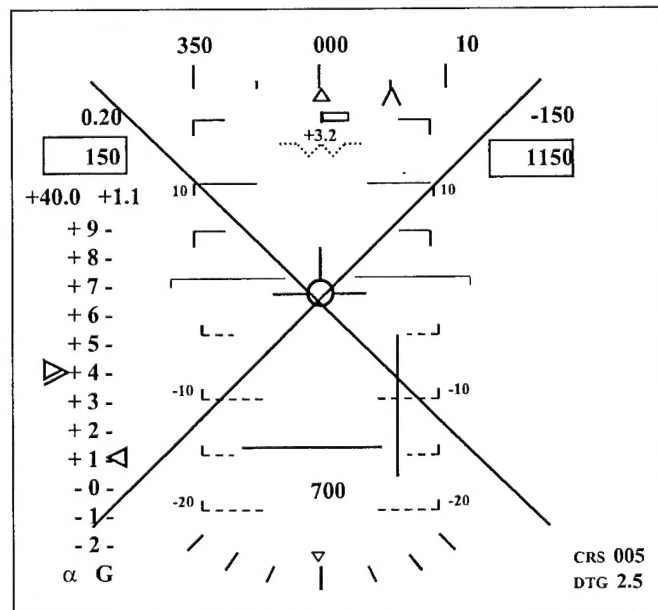
- Annunciator boxes
- Selected heading
- Commanded AOA pointer
- Commanded altitude pointer
- Needles
- Height above touchdown (HAT)
- Selected course
- Selected course
- Distance to go (DTG)
- Acceleration caret
- Derotation cue
- Wave-off X



### Derotation Cue



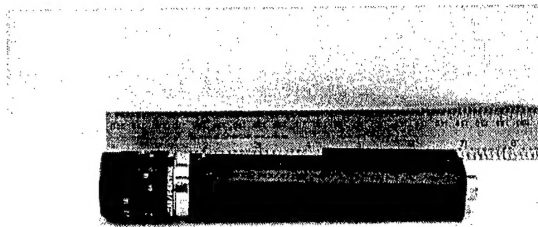
### Go Around



## *Video*

- **Provides indirect view of runway during approach**
  - Runway FOD
  - Gross alignment
    - No symbology overlay of touchdown point
- **Camera mounted internally in lower aspect of nose**
  - High alpha view of runway
  - No obstructions from nose gear
- **Display located on instrument panel behind stick**
  - Easy to scan with DDI and HUD
  - Daylight readability issues
  - Potential obstructions due to stick
- **Flight testing prior to ESTOL flights**

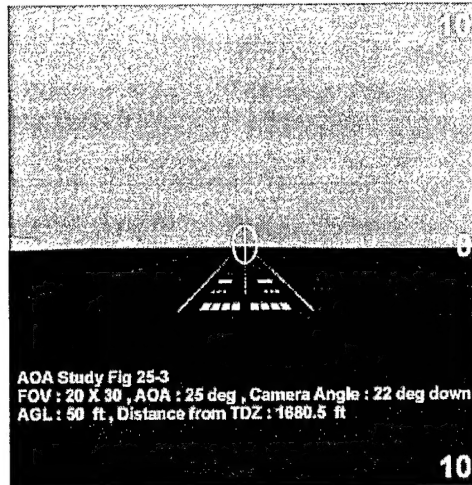
## *Camera*



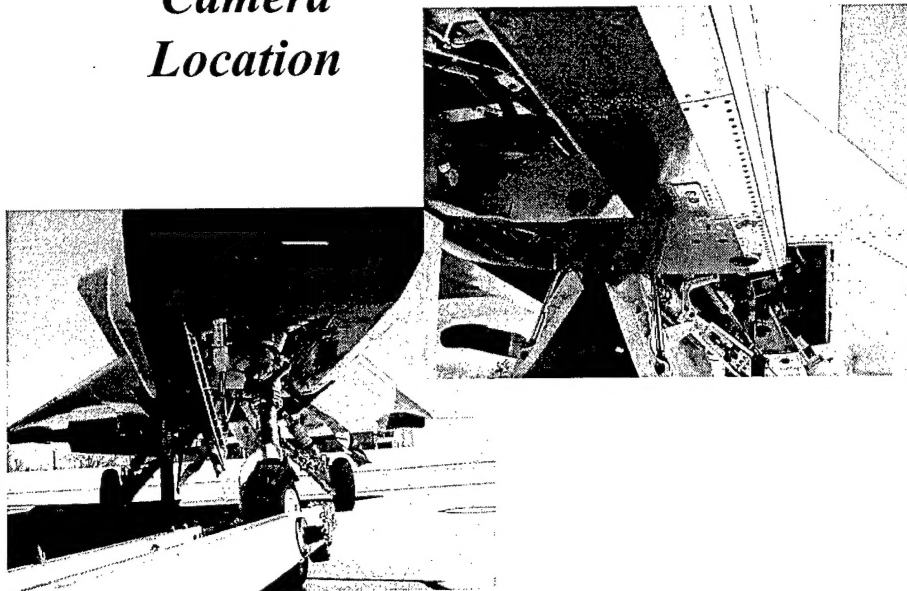
- **Ground tests to evaluate FOV of various lens**
- **Use of simulations to determine mounting angles**
- **Mounting location to provide clear view**
- **Flight tests to verify design concepts**



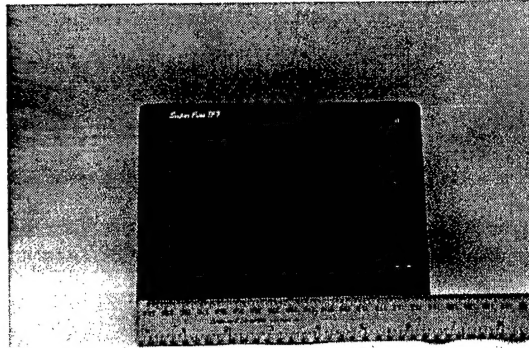
## *Simulated Video Image*



## *Camera Location*

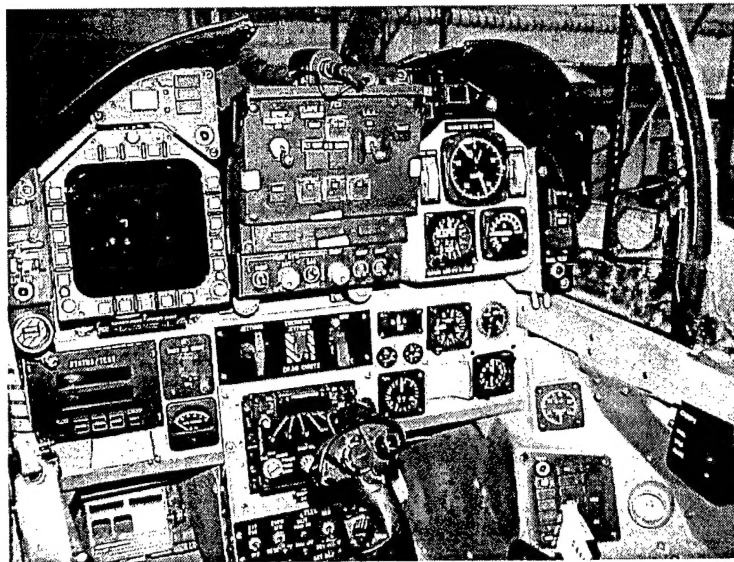


## *Display*



- Video on DDI not feasible
- Ground tests to compare off-the-shelf displays
- Flight tests to evaluate display location and video quality
  - Camera positioning, daylight readability, etc.

## *Video Display Location*



## *Summary*

**Application of human factors design concepts will enhance the safety and effectiveness of the VECTOR program.**